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# MAXIM

## Quad LVDS Line Receivers with Integrated Termination

### General Description

The MAX9125/MAX9126 quad low-voltage differential signaling (LVDS) line receivers are ideal for applications requiring high data rates, low power, and reduced noise. The MAX9125/MAX9126 are guaranteed to receive data at speeds up to 500Mbps (250MHz) over controlled-impedance media of approximately 100Ω. The transmission media may be printed circuit (PC) board traces or cables.

The MAX9125/MAX9126 accept four LVDS differential inputs and translate them to 3.3V CMOS outputs. The MAX9126 features integrated parallel termination resistors (nominally 115Ω), which eliminate the requirement for four discrete termination resistors and reduce stub length. The MAX9125 inputs are high impedance and require an external termination resistor when used in a point-to-point connection.

The devices support a wide common-mode input range of 0.05V to 2.35V, allowing for ground potential differences and common-mode noise between the driver and the receiver. A fail-safe feature sets the output high when the inputs are open, or when the inputs are undriven and shorted or parallel terminated. The EN and  $\overline{EN}$  inputs control the high-impedance output and are common to all four receivers. Inputs conform to the ANSI TIA/EIA-644 LVDS standard. The MAX9125/MAX9126 operate from a single +3.3V supply, are specified for operation from -40°C to +85°C, and are available in 16-pin TSSOP and SO packages. Refer to the MAX9124 data sheet for a quad LVDS line driver.

### Applications

- Digital Copiers
- Laser Printers
- Cellular Phone Base Stations
- Add/Drop Muxes
- Digital Cross-Connects
- DSLAMs
- Network Switches/Routers
- Backplane Interconnect
- Clock Distribution

*Pin Configuration appears at end of data sheet.*

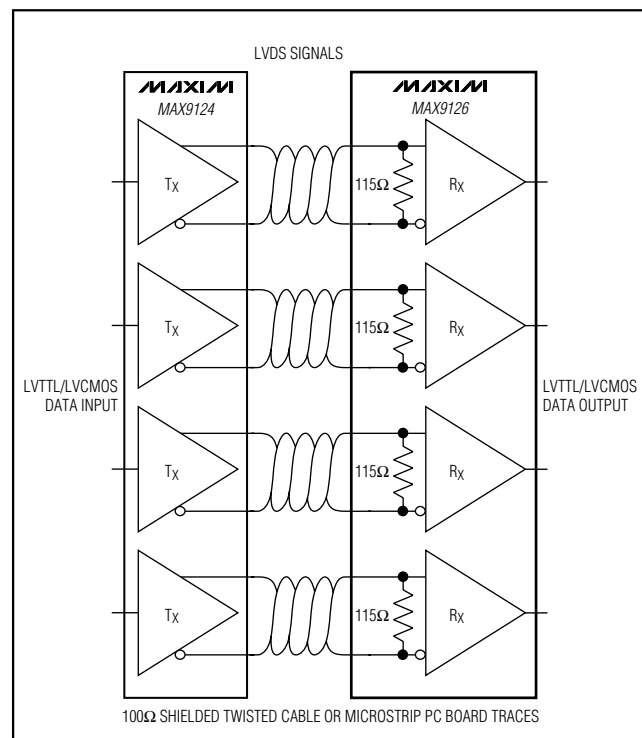
### Features

- ◆ Integrated Termination Eliminates Four External Resistors (MAX9126)
- ◆ Pin Compatible with DS90LV032A
- ◆ Guaranteed 500Mbps Data Rate
- ◆ 300ps Pulse Skew (max)
- ◆ Conform to ANSI TIA/EIA-644 LVDS Standard
- ◆ Single +3.3V Supply
- ◆ Low 70μA Shutdown Supply Current
- ◆ Fail-Safe Circuit

### Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX9125EUE	-40°C to +85°C	16 TSSOP
MAX9125ESE	-40°C to +85°C	16 SO
MAX9126EUE	-40°C to +85°C	16 TSSOP
MAX9126ESE	-40°C to +85°C	16 SO

### Typical Application Circuit



MAX9125/MAX9126

# Quad LVDS Line Receivers with Integrated Termination

## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> to GND .....	-0.3V to +4.0V	Storage Temperature Range .....	-65°C to +150°C
IN <sub>+</sub> , IN <sub>-</sub> to GND .....	-0.3V to +4.0V	Maximum Junction Temperature .....	+150°C
EN, $\overline{\text{EN}}$ to GND .....	-0.3V to (V <sub>CC</sub> + 0.3V)	Operating Temperature Range .....	-40°C to +85°C
OUT <sub>-</sub> to GND .....	-0.3V to (V <sub>CC</sub> + 0.3V)	Lead Temperature (soldering, 10s) .....	+300°C
Continuous Power Dissipation (T <sub>A</sub> = +70°C)		ESD Protection (Human Body Model) IN <sub>+</sub> , IN <sub>-</sub> , OUT <sub>-</sub> .....	±7.5kV
16-Pin TSSOP (derate 9.4mW/°C above +70°C) .....	755mW		
16-Pin SO (derate 8.7mW/°C above +70°C) .....	696mW		

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +3.0V to +3.6V, differential input voltage |V<sub>ID</sub>| = 0.1V to 1.0V, common-mode voltage V<sub>CM</sub> = |V<sub>ID</sub>|/2 to 2.4V - |V<sub>ID</sub>|/2, T<sub>A</sub> = -40°C to +85°C. Typical values are at V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>LVDS INPUTS (IN<sub>+</sub>, IN<sub>-</sub>)</b>						
Differential Input High Threshold	V <sub>TH</sub>				100	mV
Differential Input Low Threshold	V <sub>TL</sub>		-100			mV
Input Current (MAX9125)	I <sub>IN+</sub> , I <sub>IN-</sub>	0.1V ≤  V <sub>ID</sub>   ≤ 0.6V,	-20		20	μA
		0.6V <  V <sub>ID</sub>   ≤ 1.0V	-25		25	
Power-Off Input Current (MAX9125)	I <sub>IN+</sub> , I <sub>IN-</sub>	0.1V ≤  V <sub>ID</sub>   ≤ 0.6V, V <sub>CC</sub> = 0	-20		20	μA
		0.6V <  V <sub>ID</sub>   ≤ 1.0V, V <sub>CC</sub> = 0	-25		25	
Input Resistor 1	R <sub>IN1</sub>	V <sub>CC</sub> = +3.6V or 0, Figure 1	35			kΩ
Input Resistor 2	R <sub>IN2</sub>	V <sub>CC</sub> = +3.6V or 0, Figure 1	132			kΩ
Differential Input Resistance (MAX9126)	R <sub>DIFF</sub>	V <sub>CC</sub> = +3.6V or 0, Figure 1	90	115	132	Ω
<b>LVC MOS/LVTTL OUTPUTS (OUT<sub>-</sub>)</b>						
Output High Voltage	V <sub>OH</sub>	I <sub>OH</sub> = -4.0mA (MAX9125)	Open, undriven short, or undriven 100Ω parallel termination	2.7	3.2	V
			V <sub>ID</sub> = +100mV	2.7	3.2	
		I <sub>OH</sub> = -4.0mA (MAX9126)	Open or undriven short	2.7	3.2	
			V <sub>ID</sub> = +100mV	2.7	3.2	
Output Low Voltage	V <sub>OL</sub>	I <sub>OL</sub> = +4.0mA, V <sub>ID</sub> = -100mV		0.1	0.25	V
Output Short-Circuit Current	I <sub>OS</sub>	Enabled, V <sub>ID</sub> = +100mV, V <sub>OUT-</sub> = 0 (Note 2)	-15		-120	mA
Output High-Impedance Current	I <sub>OZ</sub>	Disabled, V <sub>OUT-</sub> = 0 or V <sub>CC</sub>	-10		+10	μA

# Quad LVDS Line Receivers with Integrated Termination

MAX9125/MAX9126

## DC ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +3.0V$  to  $+3.6V$ , differential input voltage  $|V_{ID}| = 0.1V$  to  $1.0V$ , common-mode voltage  $V_{CM} = |V_{ID}|/2$  to  $2.4V - |V_{ID}|/2$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ . Typical values are at  $V_{CC} = +3.3V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>LOGIC INPUTS (EN, <math>\overline{EN}</math>)</b>						
Input High Voltage	$V_{IH}$		2.0		$V_{CC}$	V
Input Low Voltage	$V_{IL}$		0		0.8	V
Input Current	$I_{IN}$	$V_{IN} = V_{CC}$ or 0	-15		15	$\mu A$
<b>SUPPLY</b>						
Supply Current	$I_{CC}$	Enabled, inputs open		9	15	mA
Disabled Supply Current	$I_{CCZ}$	Disabled, inputs open		70	500	$\mu A$

## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $C_L = 10pF$ , differential input voltage  $|V_{ID}| = 0.2V$  to  $1.0V$ , common-mode voltage  $V_{CM} = |V_{ID}|/2$  to  $2.4V - |V_{ID}|/2$ , input rise and fall time = 1ns (20% to 80%), input frequency = 100MHz,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ . Typical values are at  $V_{CC} = +3.3V$ ,  $V_{CM} = 1.2V$ ,  $|V_{ID}| = 0.2V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Notes 3, 4)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Differential Propagation Delay High to Low	$t_{PHLD}$	Figures 2 and 3	1.8	2.4	3.3	ns
Differential Propagation Delay Low to High	$t_{PLHD}$	Figures 2 and 3	1.8	2.3	3.3	ns
Differential Pulse Skew [ $t_{PHLD} - t_{PLHD}$ ] (Note 5)	$t_{SKD1}$	Figures 2 and 3		100	300	ps
Differential Channel-to-Channel Skew (Note 6)	$t_{SKD2}$	Figures 2 and 3			400	ps
Differential Part-to-Part Skew (Note 7)	$t_{SKD3}$	Figures 2 and 3			0.8	ns
Differential Part-to-Part Skew (Note 8)	$t_{SKD4}$	Figures 2 and 3			1.5	ns
Rise Time	$t_{TLH}$	Figures 2 and 3		0.34	1.2	ns
Fall Time	$t_{THL}$	Figures 2 and 3		0.32	1.2	ns
Disable Time High to Z	$t_{PHZ}$	$R_L = 2k\Omega$ , Figures 4 and 5			12	ns
Disable Time Low to Z	$t_{PLZ}$	$R_L = 2k\Omega$ , Figures 4 and 5			12	ns
Enable Time Z to High	$t_{PZH}$	$R_L = 2k\Omega$ , Figures 4 and 5			17	ns
Enable Time Z to Low	$t_{PZL}$	$R_L = 2k\Omega$ , Figures 4 and 5			17	ns
Maximum Operating Frequency (Note 9)	$f_{MAX}$	All channels switching	250	300		MHz

# Quad LVDS Line Receivers with Integrated Termination

## AC ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $C_L = 10pF$ , differential input voltage  $|V_{ID}| = 0.2V$  to  $1.0V$ , common-mode voltage  $V_{CM} = |V_{ID}|/2$  to  $2.4V - |V_{ID}|/2$ , input rise and fall time =  $1ns$  (20% to 80%), input frequency =  $100MHz$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ . Typical values are at  $V_{CC} = +3.3V$ ,  $V_{CM} = 1.2V$ ,  $|V_{ID}| = 0.2V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Notes 3, 4)

**Note 1:** Current into a pin is defined as positive. Current out of a pin is defined as negative. All voltages are referenced to ground except  $V_{TH}$ ,  $V_{TL}$ , and  $V_{ID}$ .

**Note 2:** Short only one output at a time. Do not exceed the absolute maximum junction temperature specification.

**Note 3:** AC parameters are guaranteed by design and characterization.

**Note 4:**  $C_L$  includes scope probe and test jig capacitance.

**Note 5:**  $t_{SKD1}$  is the magnitude difference of differential propagation delays in a channel;  $t_{SKD1} = |t_{PHLD} - t_{PLHD}|$ .

**Note 6:**  $t_{SKD2}$  is the magnitude difference of the  $t_{PLHD}$  or  $t_{PHLD}$  of one channel and the  $t_{PLHD}$  or  $t_{PHLD}$  of any other channel on the same part.

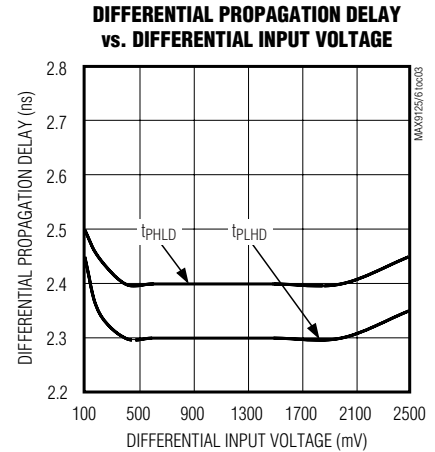
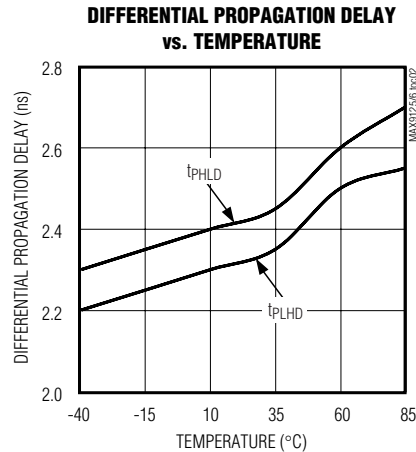
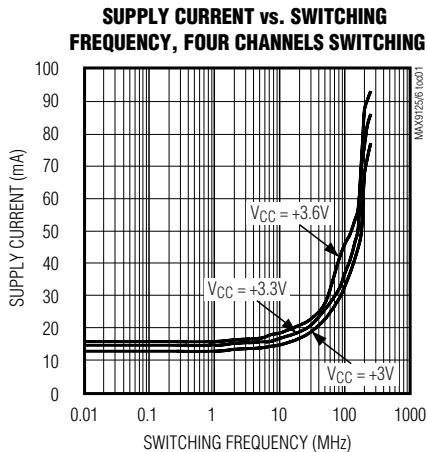
**Note 7:**  $t_{SKD3}$  is the magnitude difference of any differential propagation delays between parts operating over rated conditions at the same  $V_{CC}$  and within  $5^{\circ}C$  of each other.

**Note 8:**  $t_{SKD4}$  is the magnitude difference of any differential propagation delays between parts operating over rated conditions.

**Note 9:**  $f_{MAX}$  generator output conditions:  $t_R = t_F < 1ns$  (0% to 100%), 50% duty cycle,  $V_{OL} = 1.1V$ ,  $V_{OH} = 1.3V$ . Receiver output criteria: 60% to 40% duty cycle,  $V_{OL} = 0.4V$  (max),  $V_{OH} = 2.7V$  (min), load =  $10pF$ .

## Typical Operating Characteristics

( $V_{CC} = +3.3V$ ,  $|V_{ID}| = 200mV$ ,  $V_{CM} = +1.2V$ ,  $C_L = 10pF$ , frequency =  $10MHz$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (Figures 2 and 3)

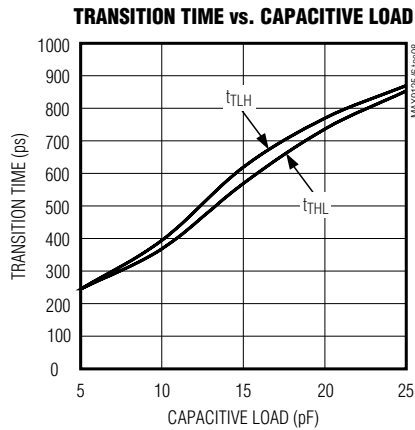
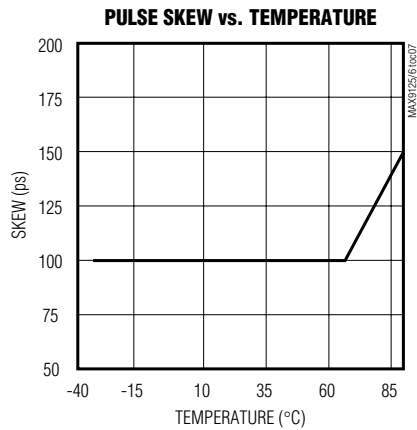
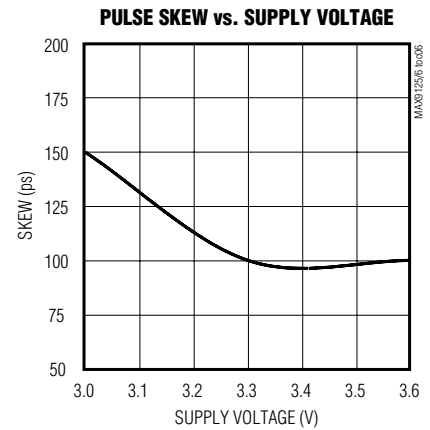
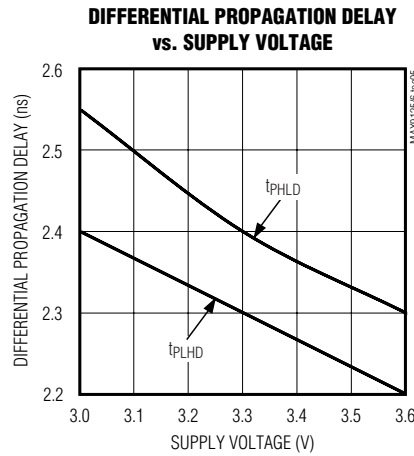
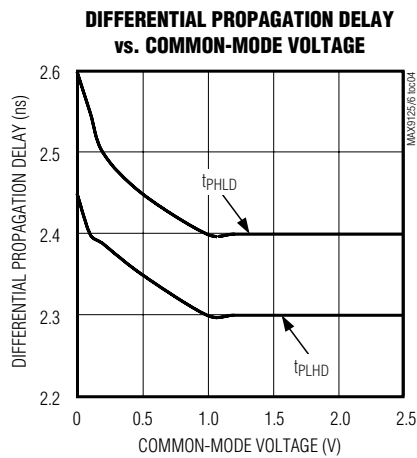


# Quad LVDS Line Receivers with Integrated Termination

MAX9125/MAX9126

## Typical Operating Characteristics (continued)

( $V_{CC} = +3.3V$ ,  $|V_{ID}| = 200mV$ ,  $V_{CM} = +1.2V$ ,  $C_L = 10pF$ , frequency = 10MHz,  $T_A = +25^\circ C$ , unless otherwise noted (Figures 2 and 3).)



## Pin Description

PIN	NAME	FUNCTION
1, 7, 9, 15	IN <sub>-</sub>	Inverting Differential Receiver Inputs
2, 6, 10, 14	IN <sub>+</sub>	Noninverting Differential Receiver Inputs
3, 5, 11, 13	OUT <sub>-</sub>	LVC MOS/LVTTL Receiver Outputs
4, 12	EN, $\overline{EN}$	Receiver Enable Inputs. When EN = low and $\overline{EN}$ = high, the outputs are disabled and in high impedance. For other combinations of EN and $\overline{EN}$ , the outputs are active.
8	GND	Ground
16	V <sub>CC</sub>	Power Supply Input. Bypass V <sub>CC</sub> to GND with 0.1 $\mu$ F and 0.001 $\mu$ F ceramic capacitors.

# Quad LVDS Line Receivers with Integrated Termination

**Table 1. Input/Output Function Table**

ENABLES		INPUTS		OUTPUT
EN	$\overline{\text{EN}}$	$(\text{IN}_+) - (\text{IN}_-)$		$\text{OUT}_-$
L	H	X		Z
All other combinations of ENABLE inputs		$V_{\text{ID}} \geq +100\text{mV}$		H
		$V_{\text{ID}} \leq -100\text{mV}$		L
		MAX9125	Open, undriven short, or undriven 100Ω parallel termination	H
		MAX9126	Open or undriven short	

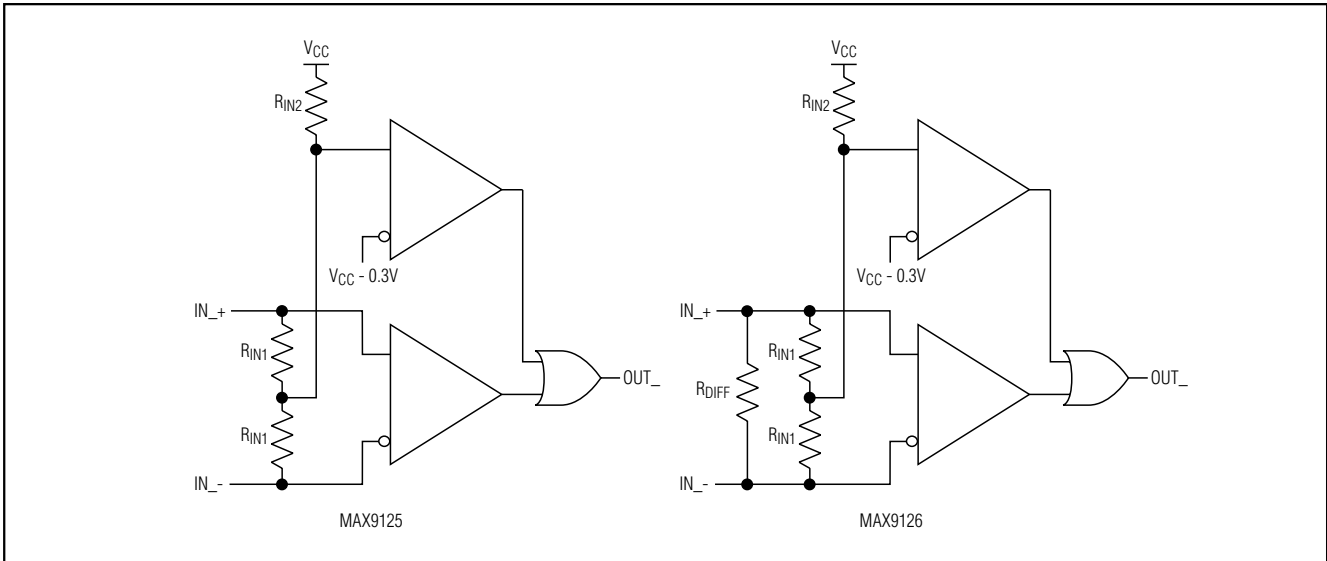


Figure 1. Inputs with Internal Fail-Safe Circuitry

## Detailed Description

The LVDS interface standard is a signaling method intended for point-to-point communication over a controlled-impedance medium as defined by the ANSI TIA/EIA-644 and IEEE 1596.3 standards. The LVDS standard uses a lower voltage swing than other common communication standards, achieving higher data rates with reduced power consumption while reducing EMI emissions and system susceptibility to noise.

The MAX9125/MAX9126 are 500Mbps, four-channel LVDS receivers intended for high-speed, point-to-point, low-power applications. Each channel accepts an LVDS input and translates it to an LVTTTL/LVCMOS output. The receiver is capable of detecting differential signals as low as 100mV and as high as 1V within an

input voltage range of 0 to 2.4V. The 250mV to 400mV differential output of an LVDS driver is nominally centered around a +1.2V offset. This offset, coupled with the receiver's 0 to 2.4V input voltage range, allows an approximate ±1V shift in the signal (as seen by the receiver). This allows for a difference in ground references of the transmitter and the receiver, the common-mode effects of coupled noise, or both. The LVDS standards specify an input voltage range of 0 to 2.4V referenced to receiver ground.

The MAX9126 has an integrated termination resistor internally connected across each receiver input. The internal termination saves board space, eases layout, and reduces “stub length” compared to an external termination resistor. In other words, the transmission line is terminated on the IC.

# Quad LVDS Line Receivers with Integrated Termination

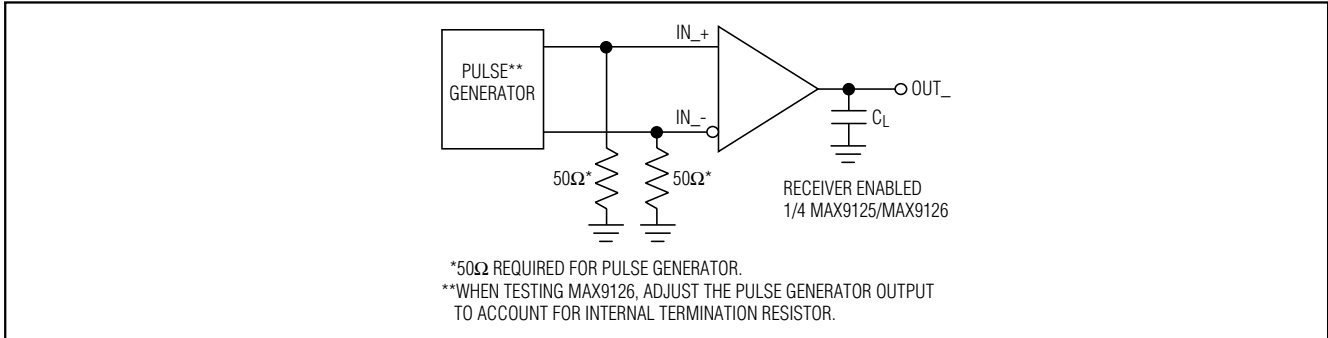


Figure 2. Transition Time and Propagation Delay Test Circuit

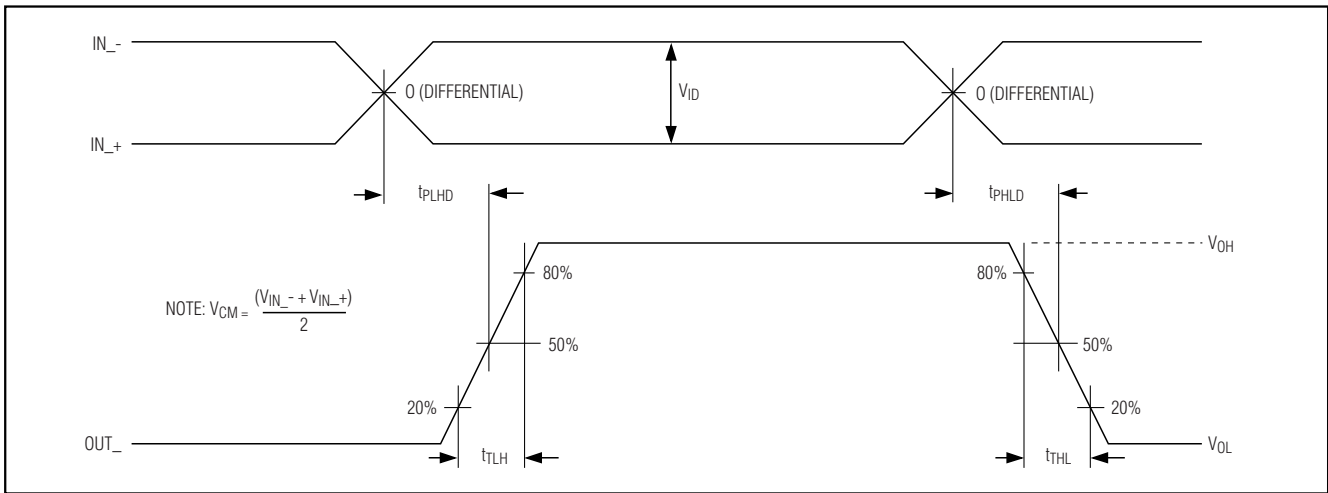


Figure 3. Transition Time and Propagation Delay Timing Diagram

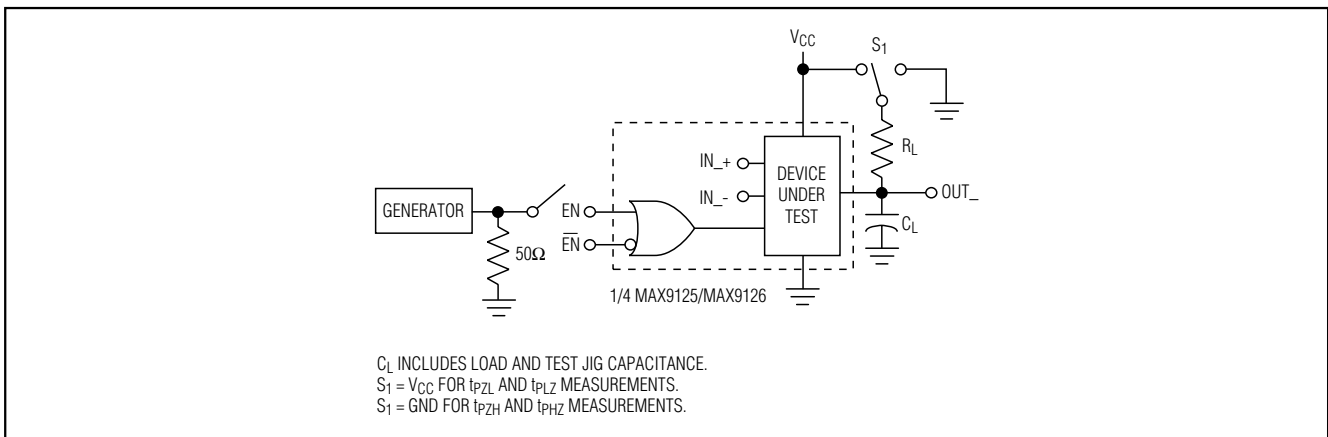


Figure 4. High-Z Delay Test Circuit

# Quad LVDS Line Receivers with Integrated Termination

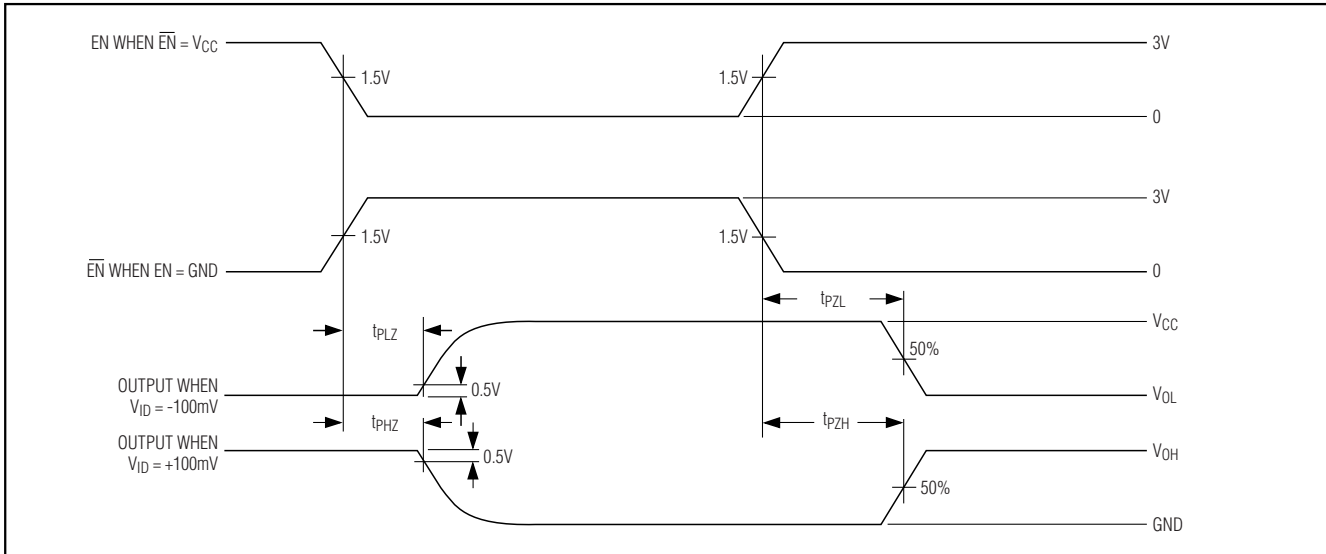


Figure 5. High-Z Delay Waveforms

## Fail-Safe

The fail-safe feature of the MAX9125/MAX9126 sets the output high when:

- Inputs are open.
- Inputs are undriven and shorted.
- Inputs are undriven and terminated.

A fail-safe circuit is important because under these conditions, noise at the inputs may switch the receiver and it may appear to the system that data is being received. Open or undriven terminated input conditions can occur when a cable is disconnected or cut, or when the LVDS driver outputs are high impedance. A short condition can occur because of a cable failure.

The fail-safe input network (Figure 1) samples the input common-mode voltage and compares it to  $V_{CC} - 0.3V$  (nominal). When the input is driven to levels specified in the LVDS standards, the input common-mode voltage is less than  $V_{CC} - 0.3V$  and the fail-safe circuit is not activated. If the inputs are open or if the inputs are undriven and shorted or undriven and parallel terminated, there is no input current. In this case, a pullup resistor in the fail-safe circuit pulls both inputs above  $V_{CC} - 0.3V$ , activating the fail-safe circuit and forcing the output high.

## Applications Information

### Power-Supply Bypassing

Bypass the  $V_{CC}$  pin with high-frequency surface-mount ceramic  $0.1\mu F$  and  $0.001\mu F$  capacitors in parallel, as close to the device as possible, with the smaller valued capacitor closest to  $V_{CC}$ .

### Differential Traces

Input trace characteristics affect the performance of the MAX9125/MAX9126. Use controlled-impedance PC board traces to match the cable characteristic impedance. The termination resistor is also matched to this characteristic impedance.

Eliminate reflections and ensure that noise couples as common mode by running the differential traces close together. Reduce skew by matching the electrical length of the traces. Excessive skew can result in a degradation of magnetic field cancellation.

Each channel's differential signals should be routed close to each other to cancel their external magnetic field. Maintain a constant distance between the differential traces to avoid discontinuities in differential impedance. Avoid  $90^\circ$  turns and vias to further prevent impedance discontinuities.

### Cables and Connectors

Transmission media typically have a controlled differential impedance of  $100\Omega$ . Use cables and connectors



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that have matched differential impedance to minimize impedance discontinuities.

Avoid the use of unbalanced cables such as ribbon or simple coaxial cable. Balanced cables such as twisted pair offer superior signal quality and tend to generate less EMI due to canceling effects. Balanced cables pick up noise as common mode, which is rejected by the LVDS receiver.

## Termination

The MAX9126 has an integrated termination resistor connected across the inputs of each receiver. The value of the integrated resistor is specified in the DC characteristics.

The MAX9125 requires an external termination resistor. The termination resistor should match the differential impedance of the transmission line. Termination resistance values range between  $90\Omega$  and  $132\Omega$ , depending on the characteristic impedance of the transmission medium.

When using the MAX9125, minimize the distance between the input termination resistors and the MAX9125 receiver inputs. Use 1% surface-mount resistors.

## Board Layout

Keep the LVDS and any other digital signals separated from each other to reduce crosstalk.

For LVDS applications, use a four-layer PC board that provides separate power, ground, LVDS signals, and output signals. Isolate the input LVDS signals from the output LVCMOS/LVTTL signals to prevent coupling. Separate the input LVDS signal plane from the LVCMOS/LVTTL output signal plane with the power and ground planes for best results.

## Chip Information

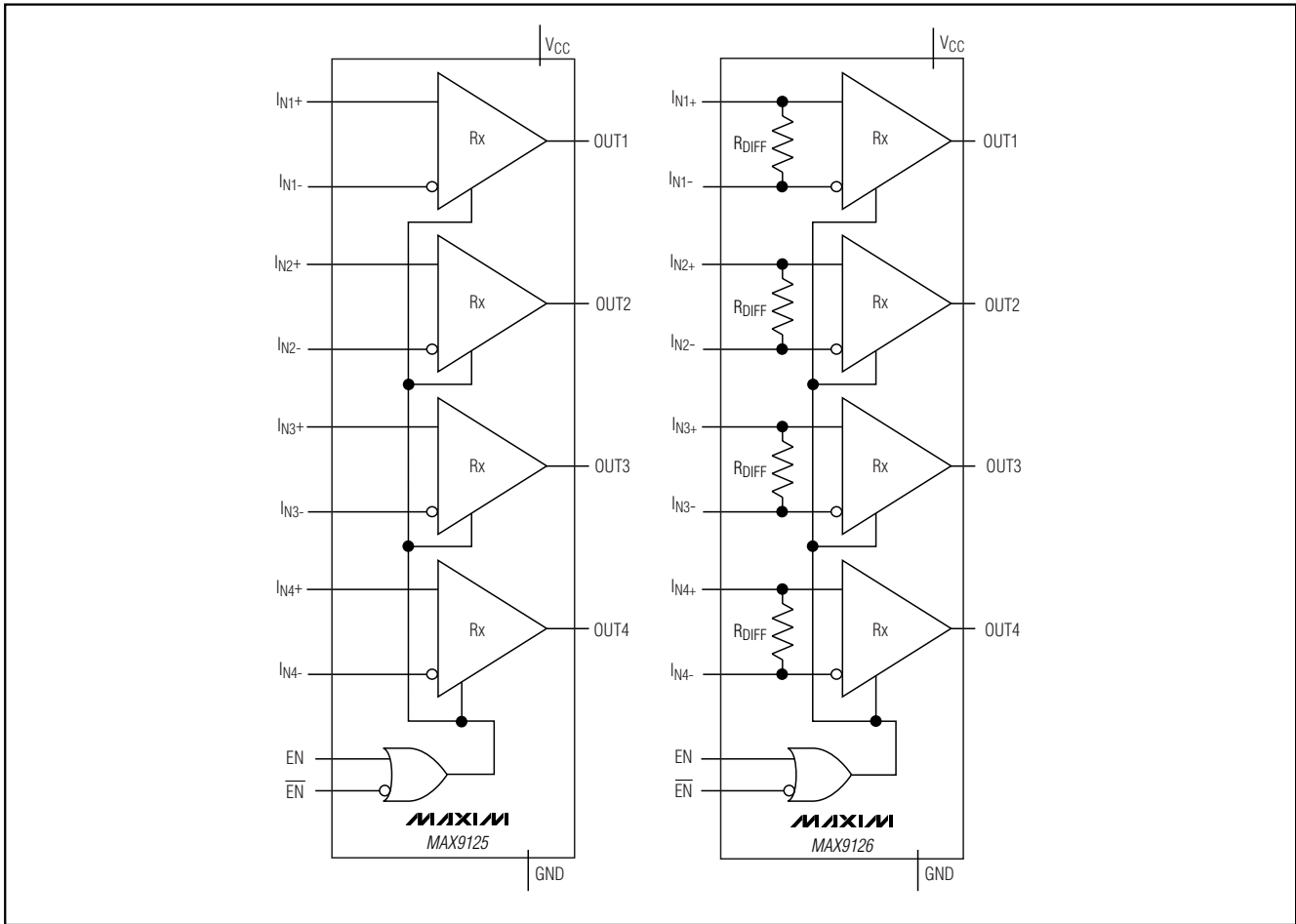
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PROCESS: CMOS

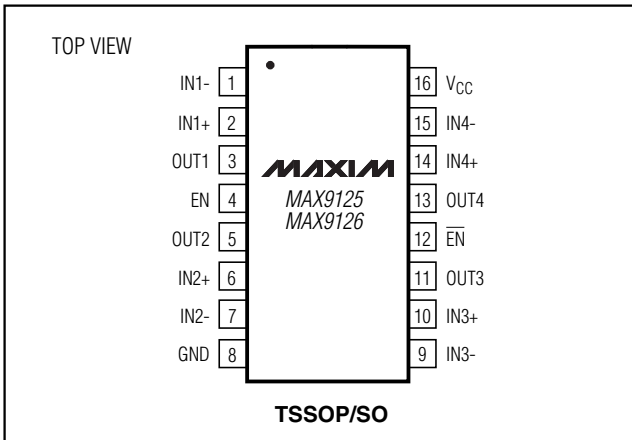
MAX9125/MAX9126

# Quad LVDS Line Receivers with Integrated Termination

**Functional Diagram**



## Pin Configuration

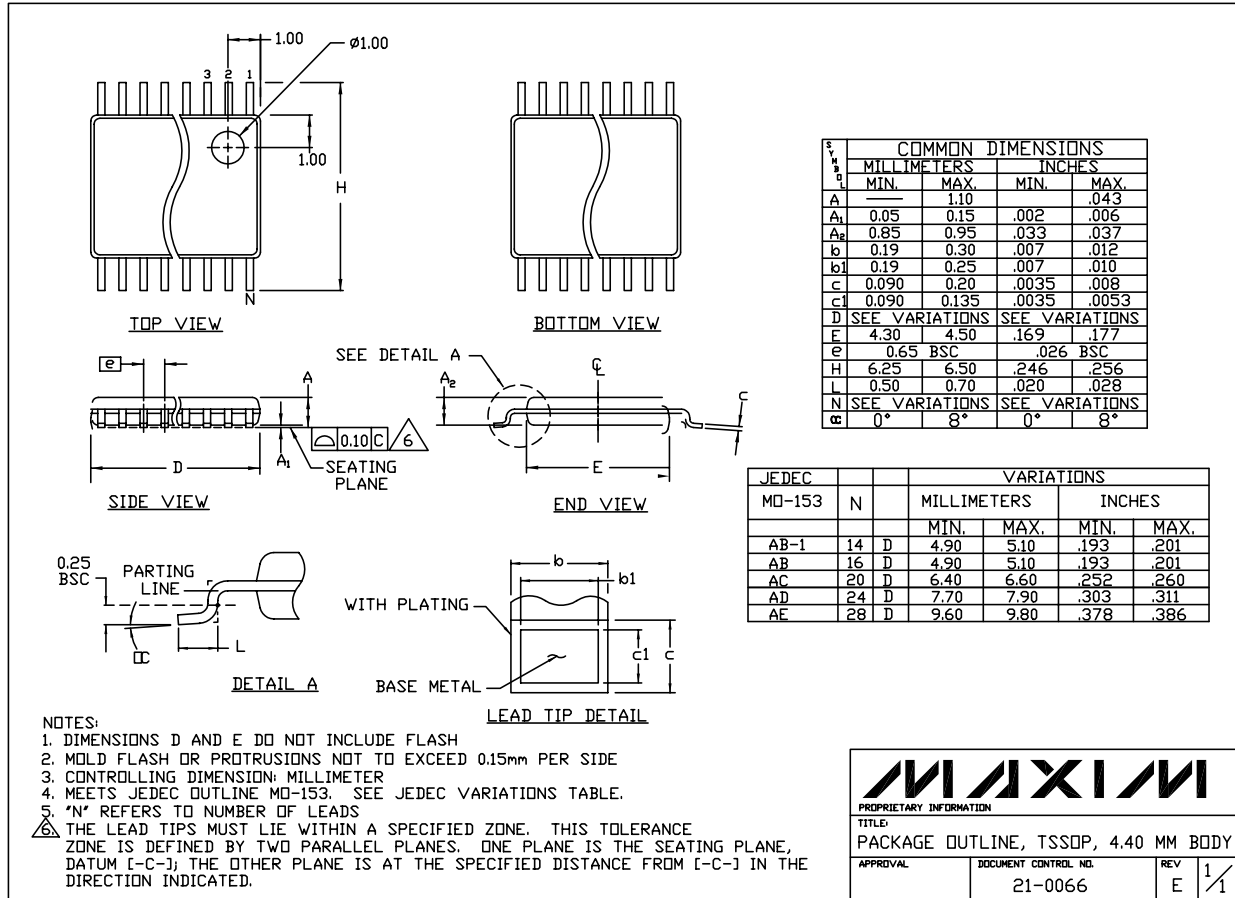


# Quad LVDS Line Receivers with Integrated Termination

## Package Information

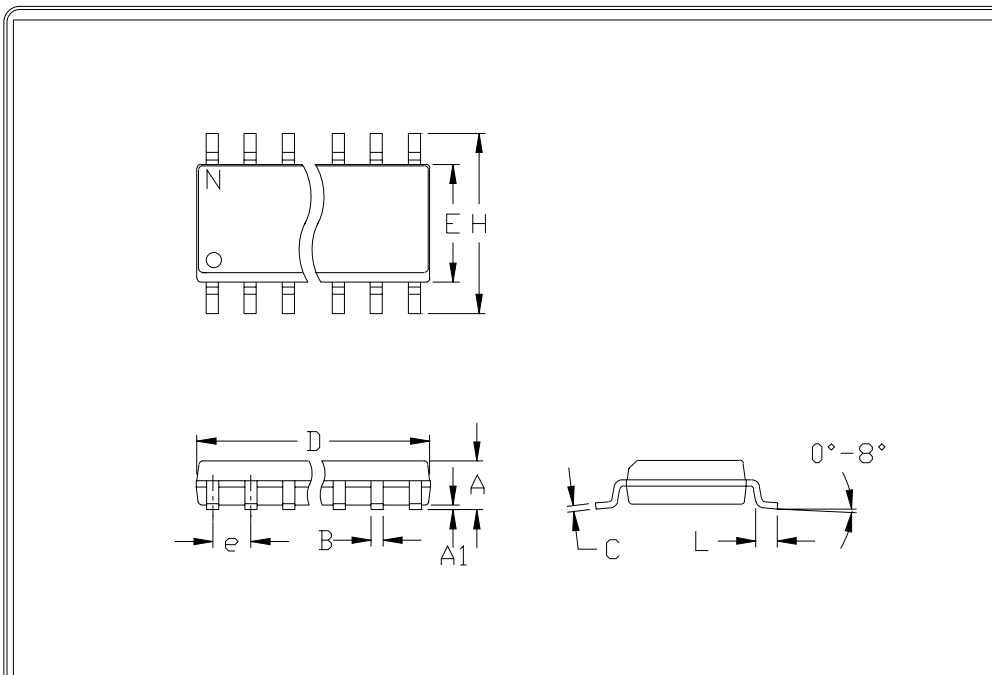
MAX9125/MAX9126

TSSOP, NO PADS, EPS



# Quad LVDS Line Receivers with Integrated Termination

## Package Information (continued)



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS		N	MS012
	MIN	MAX	MIN	MAX		
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

- NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
  2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
  3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
  4. CONTROLLING DIMENSION: MILLIMETER
  5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
  6. N = NUMBER OF PINS

 <small>120 SAN GABRIEL DR. SUNNYVALE CA 94086 FAX (408) 737-7794</small> <small>PROPRIETARY INFORMATION</small>	PACKAGE FAMILY OUTLINE: SOIC .150"	1/1	21-0041 A
	TITLE	DOCUMENT CONTROL NUMBER	REV

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

12 \_\_\_\_\_ **Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**